

INS8250 Asynchronous Communications Element

General Description

The INS8250 is a programmable Asynchronous Communications Element (ACE) chip contained in a standard 40-pin dual-in-line package. The chip, which is fabricated using N-channel silicon gate technology, functions as a serial data input/output interface in a microcomputer system. The functional configuration of the INS8250 is programmed by the system software via a TRI-STATE® 8-bit bidirectional data bus.

The INS8250 performs serial-to-parallel conversion on data characters received from a peripheral device or a MODEM, and parallel-to-serial conversion on data characters received from the CPU. The CPU can read the complete status of the INS8250 at any time during the functional operation. Status information reported includes the type and condition of the transfer operations being performed by the INS8250, as well as any error conditions (parity, overrun, framing, or break interrupt).

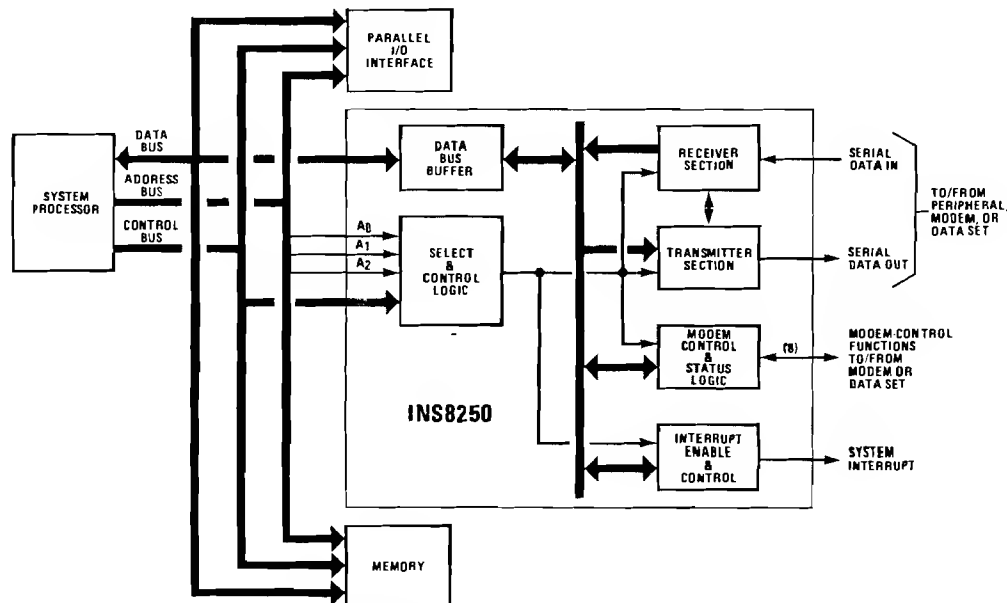
In addition to providing control of asynchronous data communications, the INS8250 includes a programmable Baud Generator that is capable of dividing the timing reference clock input by divisors of 1 to $(2^{16} - 1)$, and producing a 16x clock for driving the internal transmitter logic. Provisions are also included to use this 16x clock to drive the receiver logic. Also included in the INS8250 is a complete MODEM-control capability, and a processor-interrupt system that may be software tailored to the user's requirements to minimize the computing time required to handle the communications link.

Features

- Designed to be Easily Interfaced to Most Popular Microprocessors (SC/MP, PACE, 8080A, 6800, etc.)

- Adds or Deletes Standard Asynchronous Communication Bits (Start, Stop, and Parity) to or from Serial Data Stream
- Full Double Buffering Eliminates Need for Precise Synchronization
- Independently Controlled Transmit, Receive, Line Status, and Data Set Interrupts
- Programmable Baud Rate Generator Allows Division of Any Input Clock by 1 to $(2^{16} - 1)$ and Generates the Internal 16x Clock
- Independent Receiver Clock Input
- MODEM Control Functions (CTS, RTS, DSR, DTR, RI, and Carrier Detect)
- Fully Programmable Serial-Interface Characteristics
 - 5-, 6-, 7-, or 8-Bit Characters
 - Even, Odd, or No-Parity Bit Generation and Detection
 - 1-, 1½-, or 2-Stop Bit Generation
 - Baud Rate Generation (DC to 56k Baud)
- False Start Bit Detection
- Complete Status Reporting Capabilities
- TRI-STATE TTL Drive Capabilities for Bidirectional Data Bus and Control Bus
- Line Break Generation and Detection
- Internal Diagnostic Capabilities
 - Loopback Controls for Communications Link Fault Isolation
 - Break, Parity, Overrun, Framing Error Simulation
- Full Prioritized Interrupt System Controls
- Single +5-Volt Power Supply

INS8250 General System Configuration



Absolute Maximum Ratings

Temperature Under Bias 0°C to +70°C
 Storage Temperature -65°C to +150°C
 All Input or Output Voltages with Respect to V_{SS} -0.5 V to +7.0 V
 Power Dissipation 400 mW

Absolute maximum ratings indicate limits beyond which permanent damage may occur. Continuous operation at these limits is not intended; operation should be limited to those conditions specified under DC Electrical Characteristics.

DC Electrical Characteristics

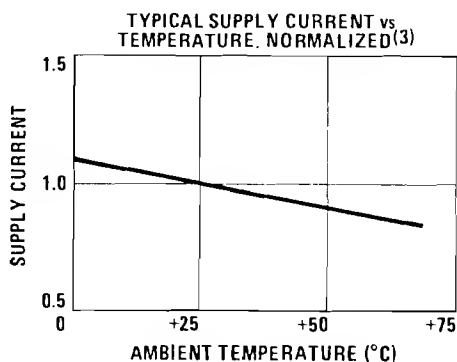
T_A = 0°C to +70°C, V_{CC} = +5 V ± 5%, V_{SS} = 0 V, unless otherwise specified.

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
V _{ILX}	Clock Input Low Voltage	-0.5		0.8	V	$I_{OL} = 1.6 \text{ mA}$ on all outputs, $I_{OH} = -100 \mu\text{A}$
V _{IHX}	Clock Input High Voltage	2.0		V _{CC}	V	
V _{IL}	Input Low Voltage	-0.5		0.8	V	
V _{IH}	Input High Voltage	2.0		V _{CC}	V	
V _{OL}	Output Low Voltage			0.4	V	
V _{OH}	Output High Voltage	2.4			V	
I _{CC} (AV)	Avg Power Supply Current (V _{CC})		65	80	mA	
I _{IL}	Input Leakage			±10	μA	
I _{CL}	Clock Leakage			±10	μA	

Capacitance

T_A = 25°C, V_{CC} = V_{SS} = 0 V

Symbol	Parameter	Typ	Max	Units	Test Conditions
C _{XIN}	Clock Capacitance	10	15	pF	$f_C = 1 \text{ MHz}$ Unmeasured pins returned to V _{SS}
C _{IN}	Input Capacitance	6	10	pF	
C _{OUT}	Output Capacitance	10	20	pF	



AC Electrical Characteristics

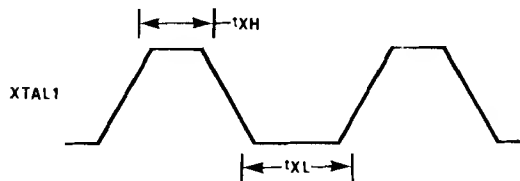
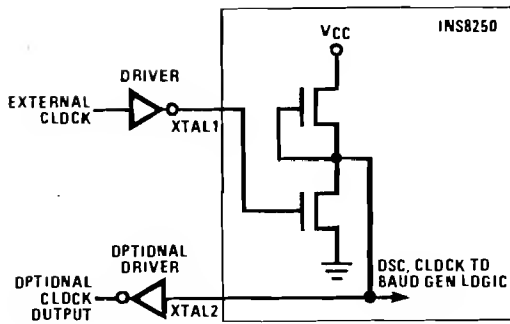
$T_A = 0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$, $V_{CC} = +5\text{ V} \pm 5\%$

Symbol	Parameter	Typical	Units	Test Conditions
t _{AW}	Address Strobe Width	100	ns	
t _{AS}	Address Setup Time	110	ns	
t _{AH}	Address Hold Time	10	ns	
t _{CSS}	Chip Select Output Delay from Strobe	100	ns	
t _{DID}	$\overline{\text{DISTR}}$ /DISTR Strobe Delay	100	ns	
t _{DIW}	$\overline{\text{DISTR}}$ /DISTR Strobe Width	200	ns	
t _{RC}	Read Cycle Delay	2000	ns	
RC	Read Cycle = t _{AW} + t _{DID} + t _{DIW} + t _{RC}	2400	ns	
t _{DD}	$\overline{\text{DISTR}}$ /DISTR to Driver Disable Delay	150	ns	
t _{DDD}	Delay from $\overline{\text{DISTR}}$ /DISTR to Data	250	ns	
t _{HZ}	$\overline{\text{DISTR}}$ /DISTR to Floating Data Delay	100	ns	
t _{DOD}	$\overline{\text{DOSTR}}$ /DOSTR Strobe Delay	200	ns	
t _{DOW}	$\overline{\text{DOSTR}}$ /DOSTR Strobe Width	200	ns	
t _{WC}	Write Cycle Delay	2000	ns	
WC	Write Cycle = t _{AW} + t _{DOD} + t _{DOW} + t _{WC}	2500	ns	
t _{DS}	Data Setup Time	200	ns	
t _{DH}	Data Hold Time	50	ns	
t _{CSC}	Chip Select Output Delay from Select	200	ns	
t _{DIC}	$\overline{\text{DISTR}}$ /DISTR Delay from Select	200	ns	
t _{DOC*}	$\overline{\text{DOSTR}}$ /DOSTR Delay from Select	200	ns	

* Applicable only when $\overline{\text{ADS}}$ input is not tied permanently low.

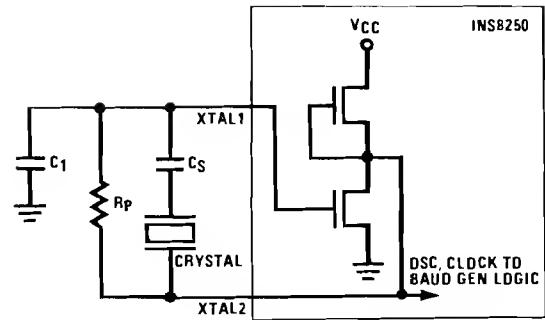
AC Electrical Characteristics (cont'd.)

Symbol	Parameter	Min	Max	Units	Test Conditions
BAUD GENERATOR					
N	Baud Rate Divisor	1	216 - 1		
t _{BLD}	Baud Output Negative Edge Delay		250 typ	ns	100 pF Load
t _{BHD}	Baud Output Positive Edge Delay		250 typ	ns	100 pF Load
t _{LW}	Baud Output Down Time	425 typ		ns	100 pF Load
t _{HW}	Baud Output Up Time	330 typ		ns	100 pF Load
RECEIVER					
t _{SCD}	Delay from RCLK to Sample Time		2 typ	μs	
t _{SINT}	Delay from Stop to Set Interrupt		2 typ	μs	100 pF Load
t _{RINT}	Delay from $\overline{\text{DISTR}}$ /DISTR (RD RBR) to Reset Interrupt		1 typ	μs	100 pF Load
TRANSMITTER					
t _{HR}	Delay from $\overline{\text{DOSTR}}$ /DOSTR (WR THR) to Reset Interrupt		1 typ	μs	100 pF Load
t _{IRS}	Delay from Initial INTR Reset to Transmit Start		16 typ	BAUDOUT Cycles	
t _{SI}	Delay from Initial Write to Interrupt		24 typ	BAUDOUT Cycles	
t _{SS}	Delay from Stop to Next Start		1 typ	μs	
t _{STI}	Delay from Stop to Interrupt (THRE)		8 typ	BAUDOUT Cycles	
t _{IR}	Delay from $\overline{\text{DISTR}}$ /DISTR (RD IIR) to Reset Interrupt (THRE)		1 typ	μs	100 pF Load
MODEM CONTROL					
t _{MDO}	Delay from $\overline{\text{DOSTR}}$ /DOSTR (WR MCR) to Output		1 typ	μs	100 pF Load
t _{SIM}	Delay to Set Interrupt from MODEM Input		1 typ	μs	100 pF Load
t _{IRM}	Delay to Reset Interrupt from $\overline{\text{DISTR}}$ /DISTR (RD MSR)		1 typ	μs	100 pF Load



Timing	Min	Units
t_{XH}	100	ns
t_{XL}	115	ns

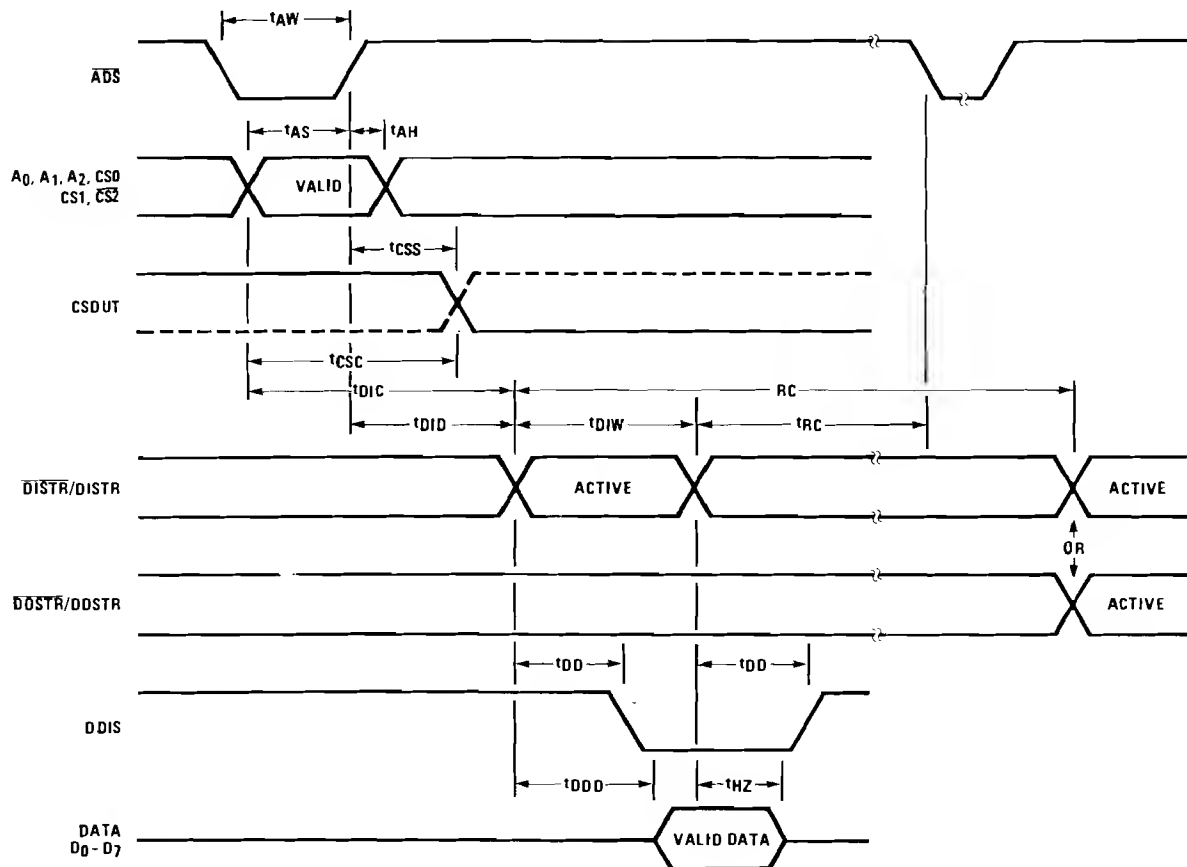
A. External Clock Input (3.1 MHz Max.)



CRYSTAL	R_p	C_S	C_1
3.1 MHz	1 M Ω	50 pF	10 pF

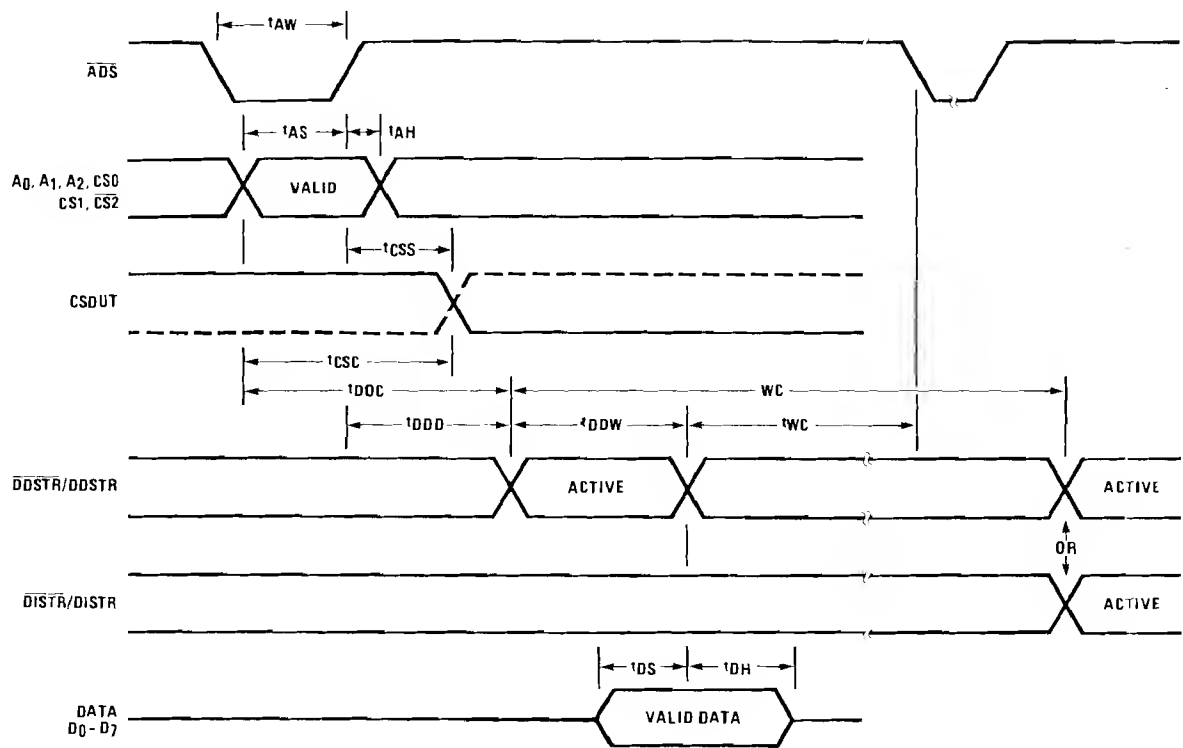
B. Typical Crystal Oscillator Network

Timing Waveforms

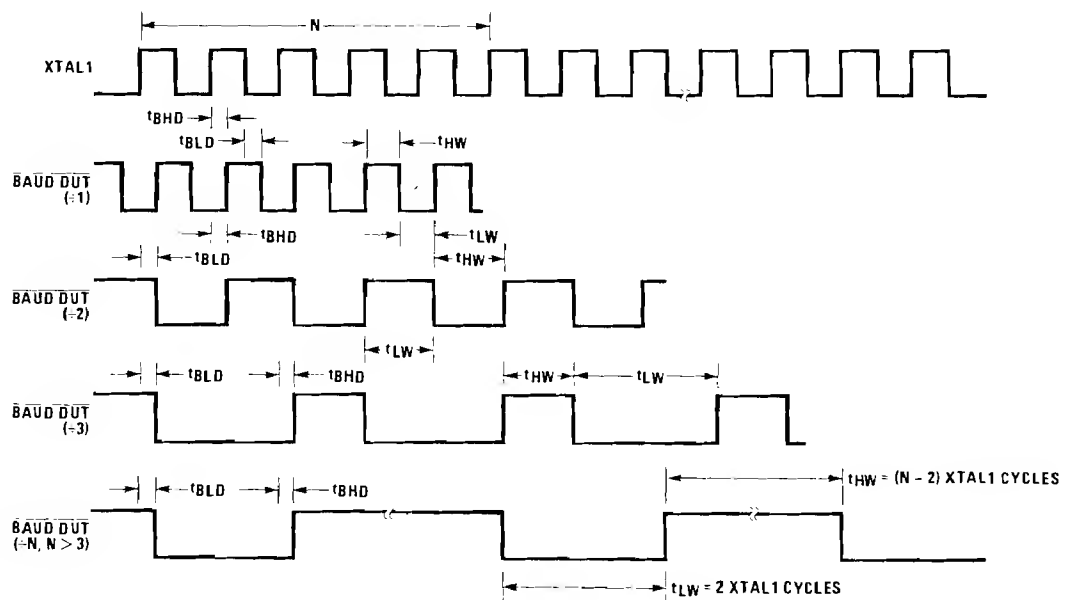


Read Cycle

Timing Waveforms (cont'd.)

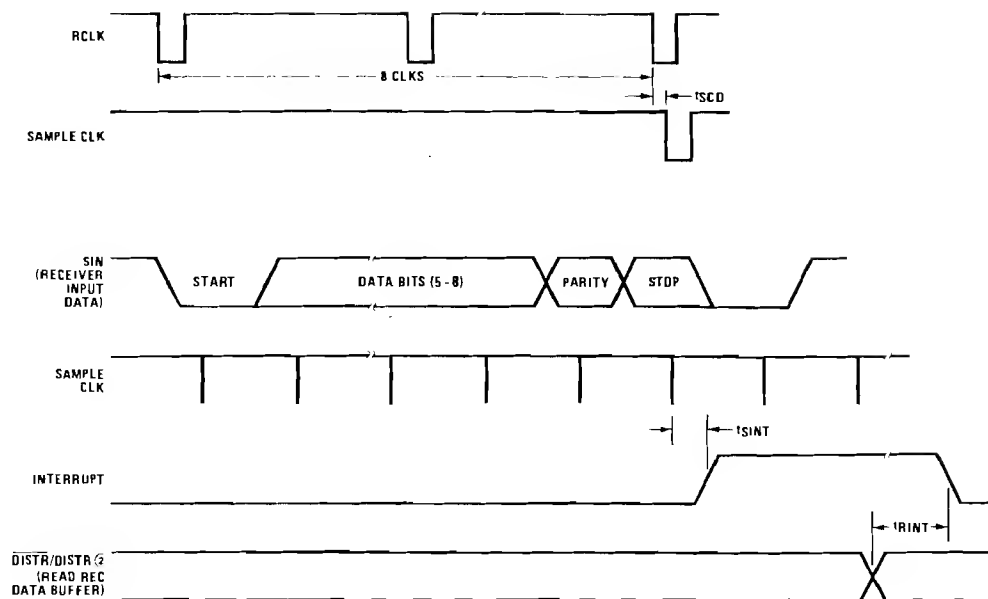


Write Cycle

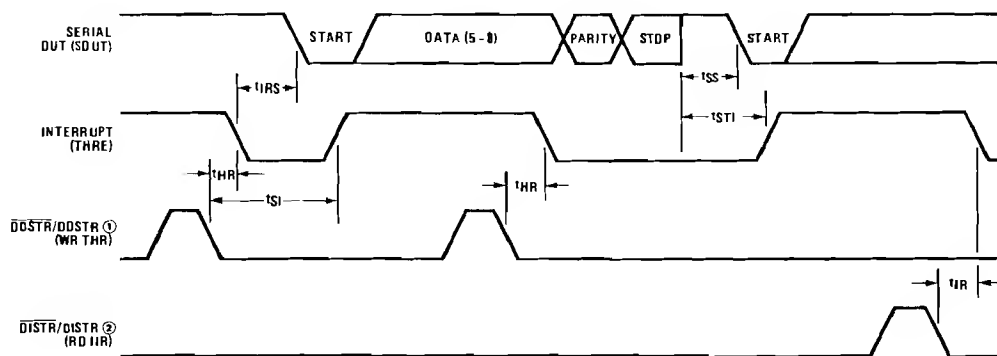


BAUDOUT Timing

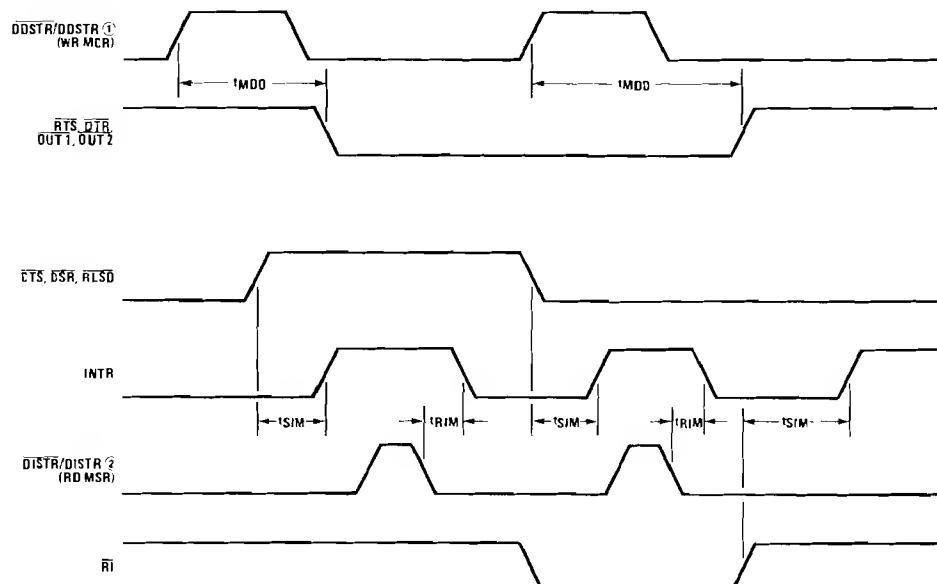
Timing Waveforms (cont'd.)



Receiver Timing



Transmitter Timing

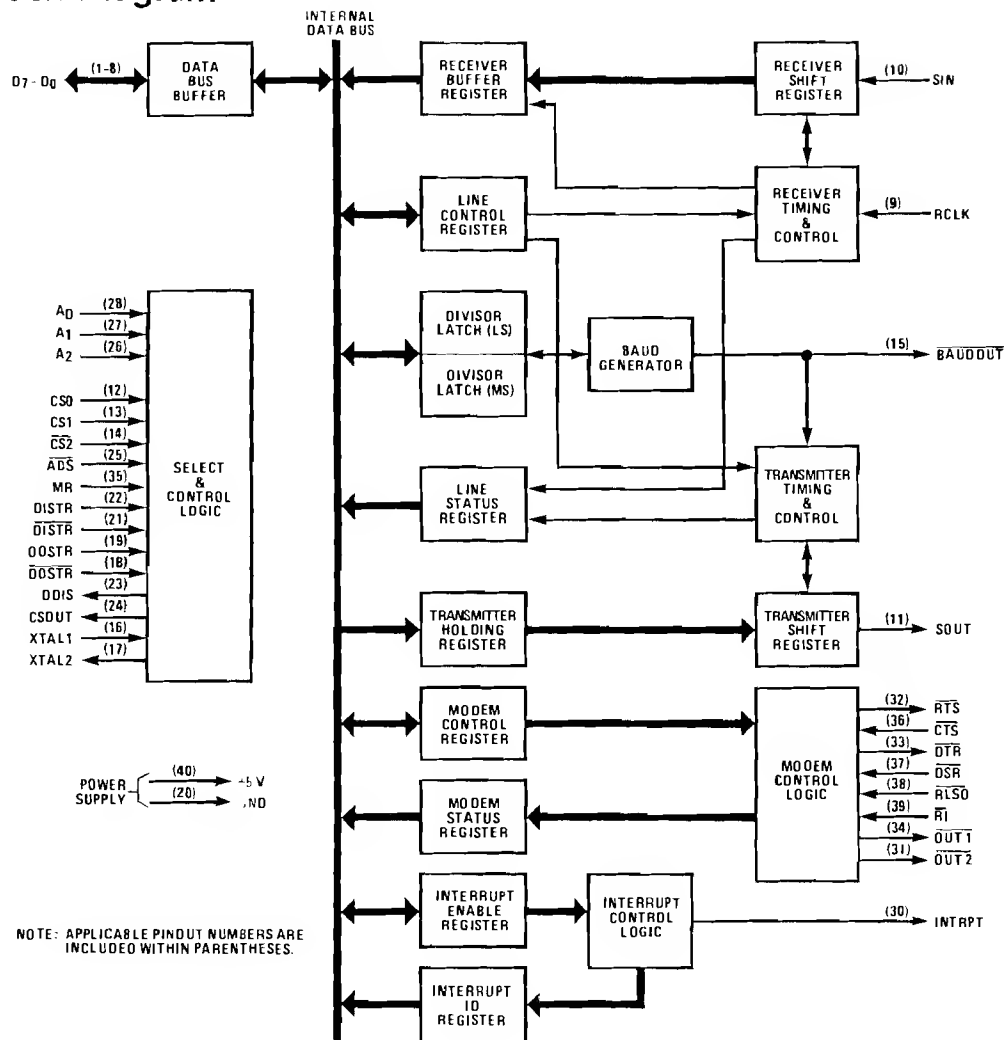


NOTES:

- ① See Write Cycle Timing
- ② See Read Cycle Timing

MODEM Controls Timing

INS8250 Block Diagram



INS8250 Functional Pin Description

The following describes the function of all INS8250 input/output pins. Some of these descriptions reference internal circuits.

NOTE

In the following descriptions, a low represents a logic 0 (0 volt nominal) and a high represents a logic 1 (+2.4 volts nominal).

INPUT SIGNALS

Chip Select (CS0, CS1, $\overline{\text{CS2}}$), Pins 12-14: When CS0 and CS1 are high and $\overline{\text{CS2}}$ is low, the chip is selected. Chip selection is complete when the decoded chip select signal is latched with an active (low) Address Strobe ($\overline{\text{ADS}}$) input. This enables communication between the INS8250 and the CPU.

Data Input Strobe (DISTR, $\overline{\text{DISTR}}$), Pins 22 and 21: When DISTR is high or $\overline{\text{DISTR}}$ is low while the chip is selected, allows the CPU to read status information or data from a selected register of the INS8250.

NOTE

Only an active DISTR or $\overline{\text{DISTR}}$ input is required to transfer data from the INS8250 during a read operation. Therefore, tie either the DISTR input permanently low or the $\overline{\text{DISTR}}$ input permanently high, if not used.

Data Output Strobe (DOSTR, $\overline{\text{DOSTR}}$), Pins 19 and 18: When DOSTR is high or $\overline{\text{DOSTR}}$ is low while the chip is selected, allows the CPU to write data or control words into a selected register of the INS8250.

NOTE

Only an active DOSTR or $\overline{\text{DOSTR}}$ input is required to transfer data to the INS8250 during a write operation. Therefore, tie either the DOSTR input permanently low or the $\overline{\text{DOSTR}}$ input permanently high, if not used.

Address Strobe ($\overline{\text{ADS}}$), Pin 25: When low, provides latching for the Register Select (A0, A1, A2) and Chip Select (CS0, CS1, $\overline{\text{CS2}}$) signals.

NOTE

An active $\overline{\text{ADS}}$ input is required when the Register Select (A0, A1, A2) signals are not stable for the duration of a read or write operation. If not required, tie the $\overline{\text{ADS}}$ input permanently low.

Register Select (A0, A1, A2), Pins 26-28: These three inputs are used during a read or write operation to select an INS8250 register to read from or write into as indicated in the table below. Note that the state of the Divisor Latch Access Bit (DLAB), which is the most significant bit of the Line Control Register, affects the selection of certain INS8250 registers. The DLAB is reset low when the Master Reset (MR) input is active (low); the DLAB must be set high by the system software to access the Baud Generator Divisor Latches.

DLAB	A ₂	A ₁	A ₀	Register
0	0	0	0	Receiver Buffer (read), Transmitter Holding Register (write)
0	0	0	1	Interrupt Enable
X	0	1	0	Interrupt Identification (read only)
X	0	1	1	Line Control
X	1	0	0	MODEM Control
X	1	0	1	Line Status
X	1	1	0	MODEM Status
X	1	1	1	None
1	0	0	0	Divisor Latch (least significant byte)
1	0	0	1	Divisor Latch (most significant byte)

Master Reset (MR), Pin 35: When high, clears all the registers (except the Receiver Buffer, Transmitter Holding, and Divisor Latches), and the control logic of the INS8250. Also, the state of various output signals (SOUT, INTRPT, OUT 1, OUT 2, RTS, DTR) are affected by an active MR input. (Refer to table 1.)

Receiver Clock (RCLK), Pin 9: This input is the 16x baud rate clock for the receiver section of the chip.

Serial Input (SIN), Pin 10: Serial data input from the communications link (peripheral device, MODEM, or data set).

Clear to Send (CTS), Pin 36: The CTS signal is a MODEM control function input whose condition can be tested by the CPU by reading bit 4 (CTS) of the MODEM Status Register. Bit 0 (DCTS) of the MODEM Status Register indicates whether the CTS input has changed state since the previous reading of the MODEM Status Register.

NOTE

Whenever the CTS bit of the MODEM Status Register changes state, an interrupt is generated if enabled.

Data Set Ready (DSR), Pin 37: When low, indicates that the MODEM or data set is ready to establish the communications link and transfer data with the INS8250. The DSR signal is a MODEM-control function input whose condition can be tested by the CPU by reading bit 5 (DSR) of the MODEM Status Register. Bit 1 (DDSR) of the MODEM Status Register indicates whether the DSR input has changed state since the previous reading of the MODEM Status Register.

NOTE

Whenever the DSR bit of the MODEM Status Register changes state, an interrupt is generated if enabled.

Received Line Signal Detect (RLSD), Pin 38: When low, indicates that the data carrier has been detected by the MODEM or data set. The RLSD signal is a MODEM-control function input whose condition can be tested by the CPU by reading bit 7 (RLSD) of the MODEM Status Register. Bit 3 (DRLSD) of the MODEM Status Register indicates whether the RLSD input has changed state since the previous reading of the MODEM Status Register.

NOTE

Whenever the RLSD bit of the MODEM Status Register changes state, an interrupt is generated if enabled.

Ring Indicator (RI), Pin 39: When low, indicates that a telephone ringing signal has been received by the MODEM or data set. The RI signal is a MODEM-control function input whose condition can be tested by the CPU by reading bit 6 (RI) of the MODEM Status Register. Bit 2 (TERI) of the MODEM Status Register indicates whether the RI input has changed from a low to a high state since the previous reading of the MODEM Status Register.

NOTE

Whenever the RI bit of the MODEM Status Register changes from a high to a low state, an interrupt is generated if enabled.

VCC, Pin 40: +5-volt supply.

VSS, Pin 20: Ground (0-volt) reference.

OUTPUT SIGNALS

Data Terminal Ready (DTR), Pin 33: When low, informs the MODEM or data set that the INS8250 is ready to communicate. The DTR output signal can be set to an active low by programming bit 0 (DTR) of the MODEM Control Register to a high level. The DTR signal is set high upon a Master Reset operation.

Request to Send (RTS), Pin 32: When low, informs the MODEM or data set that the INS8250 is ready to transmit data. The RTS output signal can be set to an active low by programming bit 1 (RTS) of the MODEM Control Register. The RTS signal is set high upon a Master Reset operation.

Output 1 (OUT 1), Pin 34: User-designated output that can be set to an active low by programming bit 2 (OUT 1) of the MODEM Control Register to a high level. The OUT 1 signal is set high upon a Master Reset operation.

Output 2 (OUT 2), Pin 31: User-designated output that can be set to an active low by programming bit 3 (OUT 2) of the MODEM Control Register to a high level. The OUT 2 signal is set high upon a Master Reset operation.

Chip Select Out (CSOUT), Pin 24: When high, indicates that the chip has been selected by active CS0, CS1, and CS2 inputs. No data transfer can be initiated until the CSOUT signal is a logic 1.

Driver Disable (DDIS), Pin 23: Goes low whenever the CPU is reading data from the INS8250. A high-level DDIS output can be used to disable an external transceiver (if used between the CPU and INS8250 on the D7-D0 Data Bus) at all times, except when the CPU is reading data.

Baud Out (BAUDOUT), Pin 15: 16x clock signal for the transmitter section of the INS8250. The clock rate is equal to the main reference oscillator frequency divided by the specified divisor in the Baud Generator Divisor Latches. The BAUDOUT may also be used for the receiver section by tying this output to the RCLK input of the chip.

Interrupt (INTRPT), Pin 30: Goes high whenever any one of the following interrupt sources has an active high condition: Receiver Error Flag; Received Data Available; Transmitter Holding Register Empty; and MODEM Status. The INTRPT signal is reset low upon a Master Reset operation.

Serial Output (SOUT), Pin 11: Composite serial data output to the communications link (peripheral, MODEM or data set). The SOUT signal is set to the Marking (logic 1) state upon a Master Reset operation.

INPUT/OUTPUT SIGNALS

Data (D7 - D0) Bus, Pins 1 - 8: This bus comprises eight TRI-STATE input/output lines. The bus provides bidirectional communications between the INS8250 and the CPU. Data, control words, and status information are transferred via the D7 - D0 Data Bus.

External Clock Input/Output (XTAL1, XTAL2), Pins 16 and 17: These two pins connect the main timing reference (crystal or signal clock) to the INS8250.

Pin Configuration

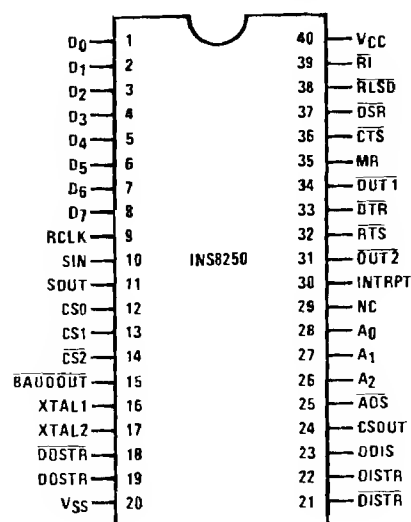


Table 1. Reset Control of Registers and Pinout Signals

Register/Signal	Reset Control	Reset State
Receiver Buffer Register	First Word Received	Data
Transmitter Holding Register	Writing into the Transmitter Holding Register	Data
Interrupt Enable Register	Master Reset	All Bits Low (0 - 3 forced and 4 - 7 permanent)
Interrupt Identification Register	Master Reset	Bit 0 is High and Bits 1 - 7 Are Permanently Low
Line Control Register	Master Reset	All Bits Low
MODEM Control Register	Master Reset	All Bits Low
Line Status Register	Master Reset	All Bits Low, Except Bits 5 & 6 Are High
MODEM Status Register	Master Reset	Bits 0 - 3 Low
	MODEM Signal Inputs	Bits 4 - 7 - Input Signal
Divisor Latch (low order bits)	Writing into the Latch	Data
Divisor Latch (high order bits)	Writing into the Latch	Data
SOUT	Master Reset	High
BAUDOUT	Writing into Either Divisor Latch	Low
CSOUT	ADS Strobe Signal and State of Chip Select Lines	High/Low
DDIS	DDIS = CSOUT · RCLK · DISTR (At Master Reset, the CPU sets RCLK and DISTR low.)	High
INTRPT	Master Reset	Low
OUT2	Master Reset	High
RTS	Master Reset	High
DTR	Master Reset	High
OUT1	Master Reset	High
D7 - D0 Data Bus Lines	In TRI-STATE Mode, Unless CSOUT · DISTR = High or CSOUT · DOSTR = High	TRI-STATE Data (ACE to CPU) Data (CPU to ACE)

INS8250 Accessible Registers

The system programmer may access or control any of the INS8250 registers summarized in table 2 via the CPU. These registers are used to control INS8250 operations and to transmit and receive data.

INS8250 LINE CONTROL REGISTER

The system programmer specifies the format of the asynchronous data communications exchange via the Line Control Register. In addition to controlling the format, the programmer may retrieve the contents of the Line Control Register for inspection. This feature simplifies system programming and eliminates the need for separate storage in system memory of the line characteristics. The contents of the Line Control Register are indicated in table 2 and are described below.

Bits 0 and 1: These two bits specify the number of bits in each transmitted or received serial character. The encoding of bits 0 and 1 is as follows:

Bit 1	Bit 0	Word Length
0	0	5 Bits
0	1	6 Bits
1	0	7 Bits
1	1	8 Bits

Bit 2: This bit specifies the number of Stop bits in each transmitted or received serial character. If bit 2 is a logic 0, 1 Stop bit is generated or checked in the transmit or receive data, respectively. If bit 2 is a logic 1 when a 5-bit word length is selected via bits 0 and 1, 1½ Stop bits are generated or checked. If bit 2 is a logic 1 when either a 6-, 7-, or 8-bit word length is selected, 2 Stop bits are generated or checked.

Table 2. Summary of INS8250 Accessible Registers

Bit No.	Register Address									
	0 DLAB = 0	0 DLAB = 0	1 DLAB = 0	2	3	4	5	6	0 DLAB = 1	1 DLAB = 1
	Receiver Buffer Register (Read Only)	Transmitter Holding Register (Write Only)	Interrupt Enable Register	Interrupt Identification Register	Line Control Register	MODEM Control Register	Line Status Register	MODEM Status Register	Divisor Latch (LS)	Divisor Latch (MS)
0	Data Bit 0*	Data Bit 0	Enable Received Data Available Interrupt (ERBFI)	"0" if Interrupt Pending	Word Length Select Bit 0 (WLS0)	Data Terminal Ready (DTR)	Data Ready (DR)	Delta Clear to Send (DCTS)	Bit 0	Bit 8
1	Data Bit 1	Data Bit 1	Enable Transmitter Holding Register Empty Interrupt (ETBEI)	Interrupt ID Bit (0)	Word Length Select Bit 1 (WLS1)	Request to Send (RTS)	Overrun Error (OR)	Delta Data Set Ready (DDSR)	Bit 1	Bit 9
2	Data Bit 2	Data Bit 2	Enable Receiver Line Status Interrupt (ELSI)	Interrupt ID Bit (1)	Number of Stop Bits (STB)	Out 1	Parity Error (PE)	Trailing Edge Ring Indicator (TERI)	Bit 2	Bit 10
3	Data Bit 3	Data Bit 3	Enable MODEM Status Interrupt (EDSSI)	0	Parity Enable (PEN)	Out 2	Framing Error (FE)	Delta Receive Line Signal Detect (DRLSD)	Bit 3	Bit 11
4	Data Bit 4	Data Bit 4	0	0	Even Parity Select (EPS)	Loop	Break Interrupt (BI)	Clear to Send (CTS)	Bit 4	Bit 12
5	Data Bit 5	Data Bit 5	0	0	Stick Parity	0	Transmitter Holding Register Empty (THRE)	Data Set Ready (DSR)	Bit 5	Bit 13
6	Data Bit 6	Data Bit 6	0	0	Set Break	0	Transmitter Shift Register Empty (TSRE)	Ring Indicator (RI)	Bit 6	Bit 14
7	Data Bit 7	Data Bit 7	0	0	Divisor Latch Access Bit (DLAB)	0	0	Received Line Signal Detect (RLSD)	Bit 7	Bit 15

* Bit 0 is the least significant bit. It is the first bit serially transmitted or received.

Bit 3: This bit is the Parity Enable bit. When bit 3 is a logic 1, a Parity bit is generated (transmit data) or checked (receive data) between the last data word bit and Stop bit of the serial data. (The Parity bit is used to produce an even or odd number of 1s when the data word bits and the Parity bit are summed.)

Bit 4: This bit is the Even Parity Select bit. When bit 3 is a logic 1 and bit 4 is a logic 0, an odd number of logic 1s is transmitted or checked in the data word bits and Parity bit. When bit 3 is a logic 1 and bit 4 is a logic 1, an even number of bits is transmitted or checked.

Bit 5: This bit is the Stick Parity bit. When bit 3 is a logic 1 and bit 5 is a logic 1, the Parity bit is transmitted and then detected by the receiver in the opposite state indicated by bit 4.

Bit 6: This bit is the Set Break Control bit. When bit 6 is a logic 1, the serial output (SOUT) is forced to the Spacing (logic 0) state and remains there (until reset by a low-level bit 6) regardless of other transmitter activity. This feature enables the CPU to alert a terminal in a computer communications system.

Bit 7: This bit is the Divisor Latch Access Bit (DLAB). It must be set high (logic 1) to access the Divisor Latches of the Baud Rate Generator during a Read or Write operation. It must be set low (logic 0) to access the Receiver Buffer, the Transmitter Holding Register, or the Interrupt Enable Register.

INS8250 PROGRAMMABLE BAUD RATE GENERATOR

The INS8250 contains a programmable Baud Rate Generator that is capable of taking any clock input (DC to 3.1 MHz) and dividing it by any divisor from 1 to $(2^{16} - 1)$. The output frequency of the Baud Generator is 16x the Baud rate. Two 8-bit latches store the divisor in a 16-bit binary format. These Divisor Latches must be loaded during initialization in order to insure desired operation of the Baud Rate Generator. Upon loading either of the Divisor Latches, a 16-bit Baud counter is immediately loaded. This prevents long counts on initial load.

Table 3. Baud Rates Using 1.8432 MHz Crystal

Desired Baud Rate	Divisor Used to Generate 16x Clock	Percent Error Difference Between Desired & Actual
50	2304	—
75	1536	—
110	1047	0.026
134.5	857	0.058
150	768	—
300	384	—
600	192	—
1200	96	—
1800	64	—
2000	58	0.69
2400	48	—
3600	32	—
4800	24	—
7200	16	—
9600	12	—
19200	6	—
38400	3	—
56000	2	2.86

NOTE: 1.8432 MHz is the standard 8080 frequency divided by 10.

Tables 3 and 4 illustrate the use of the Baud Generator with two different driving frequencies. One is referenced to a 1.8432 MHz crystal. The other is a 3.072 MHz crystal.

NOTE

The maximum operating frequency of the Baud Generator is 3.1 MHz. However, when using divisors of 5 and below, the maximum frequency is equal to the divisor in MHz. For example, if the divisor is 1, then the maximum frequency is 1 MHz. In no case should the data rate be greater than 56k Baud.

LINE STATUS REGISTER

This 8-bit register provides status information to the CPU concerning the data transfer. The contents of the Line Status Register are indicated in table 2 and are described below.

Bit 0: This bit is the receiver Data Ready (DR) indicator. Bit 0 is set to a logic 1 whenever a complete incoming character has been received and transferred into the Receiver Buffer Register. Bit 0 may be reset to a logic 0 either by the CPU reading the data in the Receiver Buffer Register or by writing a logic 0 into it from the CPU.

Bit 1: This bit is the Overrun Error (OE) indicator. Bit 1 indicates that data in the Receiver Buffer Register was not read by the CPU before the next character was transferred into the Receiver Buffer Register, thereby destroying the previous character. The OE indicator is reset whenever the CPU reads the contents of the Line Status Register.

Bit 2: This bit is the Parity Error (PE) indicator. Bit 2 indicates that the received data character does not have the correct even or odd parity, as selected by the even-parity-select bit. The PE bit is set to a logic 1 upon detection of a parity error and is reset to a logic 0 whenever the CPU reads the contents of the Line Status Register.

Table 4. Baud Rates Using 3.072 MHz Crystal

Desired Baud Rate	Divisor Used to Generate 16x Clock	Percent Error Difference Between Desired & Actual
50	3840	—
75	2560	—
110	1745	0.026
134.5	1428	0.034
150	1280	—
300	640	—
600	320	—
1200	160	—
1800	107	0.312
2000	96	—
2400	80	—
3600	53	0.628
4800	40	—
7200	27	1.23
9600	20	—
19200	10	—
38400	5	—
56000	3	14.285

Bit 3: This bit is the Framing Error (FE) indicator. Bit 3 indicates that the received character did not have a valid Stop bit. Bit 3 is set to a logic 1 whenever the Stop bit following the last data bit or parity bit is detected as a zero bit (Spacing level).

Bit 4: This bit is the Break Interrupt (BI) indicator. Bit 4 is set to a logic 1 whenever the received data input is held in the Spacing (logic 0) state for longer than a full word transmission time (that is, the total time of Start bit + data bits + Parity + Stop bits).

NOTE

Bits 1 through 4 are the error conditions that produce a Receiver Line Status interrupt whenever any of the corresponding conditions are detected.

Bit 5: This bit is the Transmitter Holding Register Empty (THRE) indicator. Bit 5 indicates that the INS8250 is ready to accept a new character for transmission. In addition, this bit causes the INS8250 to issue an interrupt to the CPU when the Transmitter Holding Register Empty Interrupt enable is set high. The THRE bit is set to a logic 1 when a character is transferred from the Transmitter Holding Register into the Transmitter Shift Register. The bit is reset to logic 0 concurrently with the loading of the Transmitter Holding Register by the CPU.

Bit 6: This bit is the Transmitter Shift Register Empty (TSRE) indicator. Bit 6 is set to a logic 1 whenever the Transmitter Shift Register is idle. It is reset to logic 0 upon a data transfer from the Transmitter Holding Register to the Transmitter Shift Register. Bit 6 is a read-only bit.

Bit 7: This bit is permanently set to logic 0.

INTERRUPT IDENTIFICATION REGISTER

The INS8250 has an on-chip interrupt capability that allows for complete flexibility in interfacing to all the popular microprocessors presently available. In order to provide minimum software overhead during data character transfers, the INS8250 prioritizes interrupts into four levels. The four levels of interrupt conditions are as follows: Receiver Line Status (priority 1); Received Data Ready (priority 2); Transmitter Holding Register Empty (priority 3); and MODEM Status (priority 4)

Information indicating that a prioritized interrupt is pending and the source of that interrupt are stored in the Interrupt Identification Register (refer to table 5). The Interrupt Identification Register (IIR), when addressed during chip-select time, freezes the highest priority interrupt pending and no other interrupts are acknowledged until the particular interrupt is serviced by the CPU. The contents of the IIR are indicated in table 2 and are described below.

Bit 0: This bit can be used in either a hardwired prioritized or polled environment to indicate whether an interrupt is pending. When bit 0 is a logic 0, an interrupt is pending and the IIR contents may be used as a pointer to the appropriate interrupt service routine. When bit 0 is a logic 1, no interrupt is pending and polling (if used) continues.

Bits 1 and 2: These two bits of the IIR are used to identify the highest priority interrupt pending as indicated in table 5.

Bits 3 through 7: These five bits of the IIR are always logic 0.

Table 5. Interrupt Control Functions

Interrupt Identification Register			Interrupt Set and Reset Functions			
Bit 2	Bit 1	Bit 0	Priority Level	Interrupt Flag	Interrupt Source	Interrupt Reset Control
0	0	1	—	None	None	—
1	1	0	Highest	Receiver Line Status	Overrun Error or Parity Error or Framing Error or Break Interrupt	Reading the Line Status Register
1	0	0	Second	Received Data Available	Receiver Data Available	Reading the Receiver Buffer Register
0	1	0	Third	Transmitter Holding Register Empty	Transmitter Holding Register Empty	Reading the IIR Register (if source of interrupt) or Writing into the Transmitter Holding Register
0	0	0	Fourth	MODEM Status	Clear to Send or Data Set Ready or Ring Indicator or Received Line Signal Detect	Reading the MODEM Status Register

INTERRUPT ENABLE REGISTER

This 8-bit register enables the four interrupt sources of the INS8250 to separately activate the chip Interrupt (INTRPT) output signal. It is possible to totally disable the interrupt system by resetting bits 0 through 3 of the Interrupt Enable Register. Similarly, by setting the appropriate bits of this register to a logic 1, selected interrupts can be enabled. Disabling the interrupt system inhibits the Interrupt Identification Register and the active (high) INTRPT output from the chip. All other system functions operate in their normal manner, including the setting of the Line Status and MODEM Status Registers. The contents of the Interrupt Enable Register are indicated in table 2 and are described below.

Bit 0: This bit enables the Received Data Available Interrupt when set to logic 1. Bit 0 is reset to logic 0 upon completion of the associated interrupt service routine.

Bit 1: This bit enables the Transmitter Holding Register Empty Interrupt when set to logic 1. Bit 1 is reset to logic 0 immediately upon reading the Interrupt Identification Register.

Bit 2: This bit enables the Receiver Line Status Interrupt when set to logic 1. Bit 2 is reset to logic 0 upon completion of the associated interrupt service routine.

Bit 3: This bit enables the MODEM Status Interrupt when set to logic 1. Bit 3 is reset to logic 0 upon completion of the associated interrupt service routine.

Bits 4 through 7: These four bits are always logic 0.

MODEM CONTROL REGISTER

This 8-bit register controls the interface with the MODEM or data set (or a peripheral device emulating a MODEM). The contents of the MODEM Control Register are indicated in table 2 and are described below.

Bit 0: This bit controls the Data Terminal Ready (\overline{DTR}) output. When bit 0 is set to a logic 1, the \overline{DTR} output is forced to a logic 0. When bit 0 is reset to a logic 0, the \overline{DTR} output is forced to a logic 1.

NOTE

The \overline{DTR} output of the INS8250 may be applied to an EIA inverting line driver (such as the DS1488) to obtain the proper polarity input at the succeeding MODEM or data set.

Bit 1: This bit controls the Request to Send (\overline{RTS}) output. Bit 1 affects the \overline{RTS} output in a manner identical to that described above for bit 0.

Bit 2: This bit controls the Output 1 ($\overline{OUT1}$) signal, which is an auxiliary user-designated output. Bit 2 affects the $\overline{OUT1}$ output in a manner identical to that described above for bit 0.

Bit 3: This bit controls the Output 2 ($\overline{OUT2}$) signal, which is an auxiliary user-designated output. Bit 3 affects the $\overline{OUT2}$ output in a manner identical to that described above for bit 0.

Bit 4: This bit provides a loopback feature for diagnostic testing of the INS8250. When bit 4 is set to logic 1, the following occur: the transmitter Serial Output (SOUT) is set to the Marking (logic 1) state; the receiver Serial Input (SIN) is disconnected; the output of the Transmitter Shift Register is "looped back" into the Receiver Shift Register input; the four MODEM Control inputs

(\overline{CTS} , \overline{DSR} , \overline{RLSD} , and \overline{RI}) are disconnected; and the four MODEM Control outputs (\overline{DTR} , \overline{RTS} , $\overline{OUT1}$, and $\overline{OUT2}$) are internally connected to the four MODEM Control inputs. In the diagnostic mode, data that is transmitted is immediately received. This feature allows the processor to verify the transmit- and receive-data paths of the INS8250.

In the diagnostic mode, the receiver and transmitter interrupts are fully operational. The MODEM Control Interrupts are also operational but the interrupts' sources are now the lower four bits of the MODEM Control Register instead of the four MODEM Control inputs. The interrupts are still controlled by the Interrupt Enable Register.

The INS8250 interrupt system can be tested by writing into the lower six bits of the Line Status Register and the lower four bits of the MODEM Status Register. Setting any of these bits to a logic 1 generates the appropriate interrupt (if enabled). The resetting of these interrupts is the same as in normal INS8250 operation. To return to this operation, the registers must be reprogrammed for normal operation and then bit 4 must be reset to logic 0.

Bits 5 through 7: These bits are permanently set to logic 0.

MODEM STATUS REGISTER

This 8-bit register provides the current state of the control lines from the MODEM (or peripheral device) to the CPU. In addition to this current-state information, four bits of the MODEM Status Register provide change information. These bits are set to a logic 1 whenever a control input from the MODEM changes state. They are reset to logic 0 whenever the CPU reads the MODEM Status Register.

The contents of the MODEM Status Register are indicated in table 2 and are described below.

Bit 0: This bit is the Delta Clear to Send (DCTS) indicator. Bit 0 indicates that the \overline{CTS} input to the chip has changed state since the last time it was read by the CPU.

Bit 1: This bit is the Delta Data Set Ready (DDSR) indicator. Bit 1 indicates that the \overline{DSR} input to the chip has changed state since the last time it was read by the CPU.

Bit 2: This bit is the Trailing Edge of Ring Indicator (TERI) detector. Bit 2 indicates that the \overline{RI} input to the chip has changed from an On (logic 1) to an Off (logic 0) condition.

Bit 3: This bit is the Delta Received Line Signal Detector (DRLSD) indicator. Bit 3 indicates that the \overline{RLSD} input to the chip has changed state.

NOTE

Whenever bit 0, 1, 2, or 3 is set to logic 1, a MODEM Status interrupt is generated.

Bit 4: This bit is the complement of the Clear to Send (\overline{CTS}) input.

Bit 5: This bit is the complement of the Data Set Ready (\overline{DSR}) input.

Bit 6: This bit is the complement of the Ring Indicator (\overline{RI}) input.

Bit 7: This bit is the complement of the Received Line Signal Detect (\overline{RLSD}) input.

Typical Applications

Figures 1 and 2 show how to use the INS8250 chip in an INS8080A system and in a microcomputer system with a high-capacity data bus.

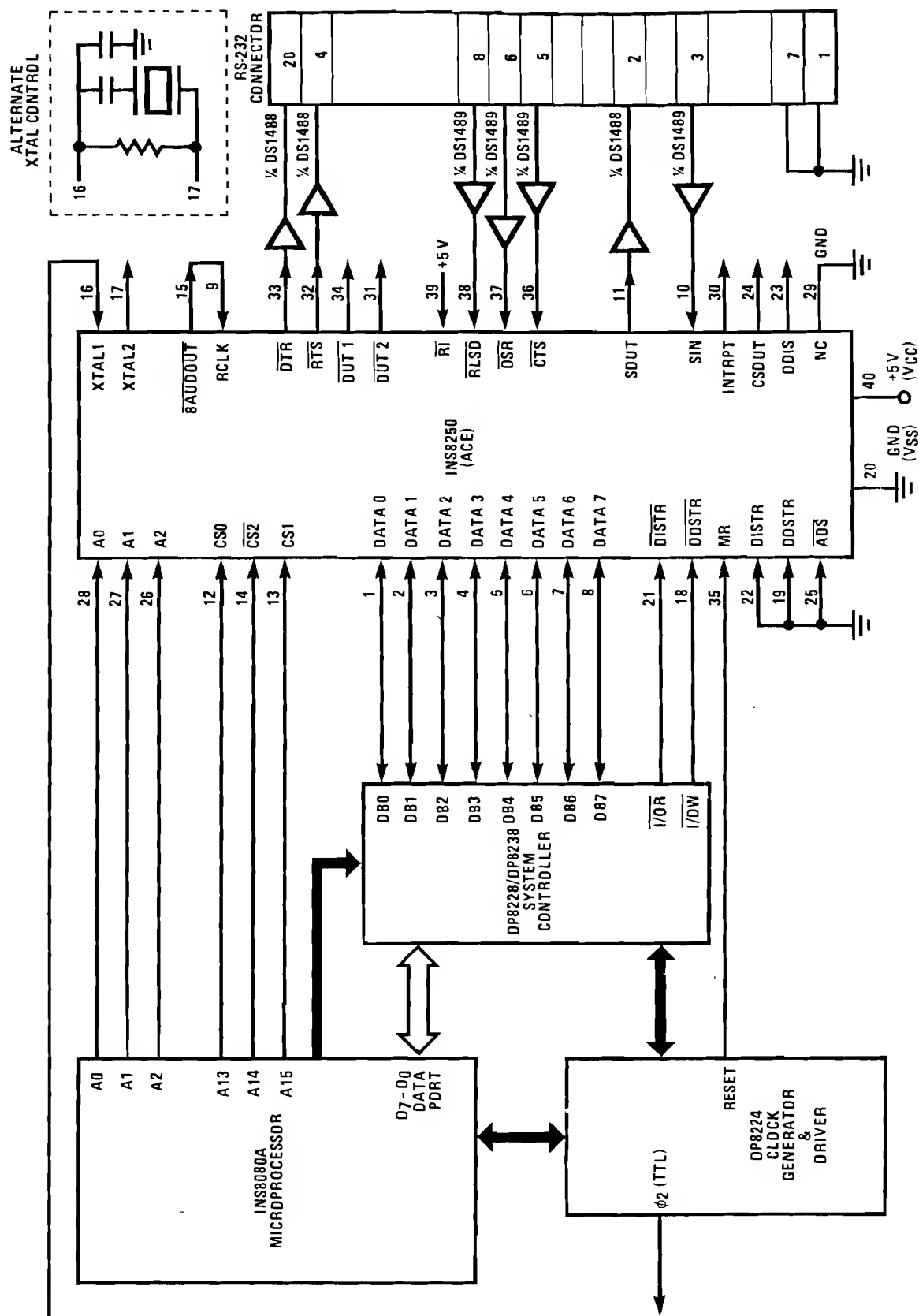


Figure 1. Typical INS8080A/INS8250 RS-232 Terminal Interface

Typical Applications (cont'd.)

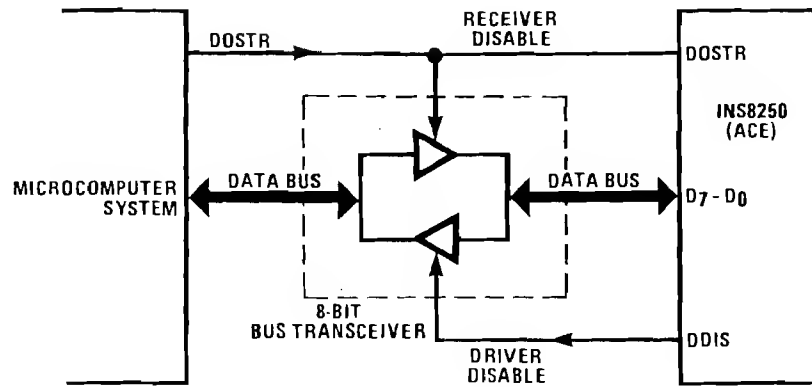
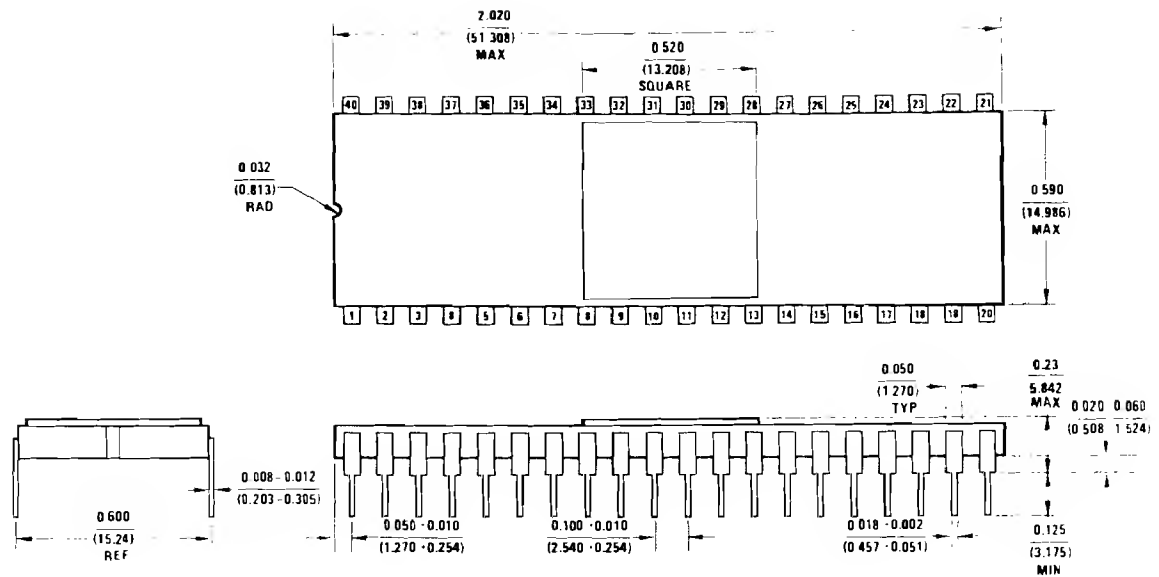
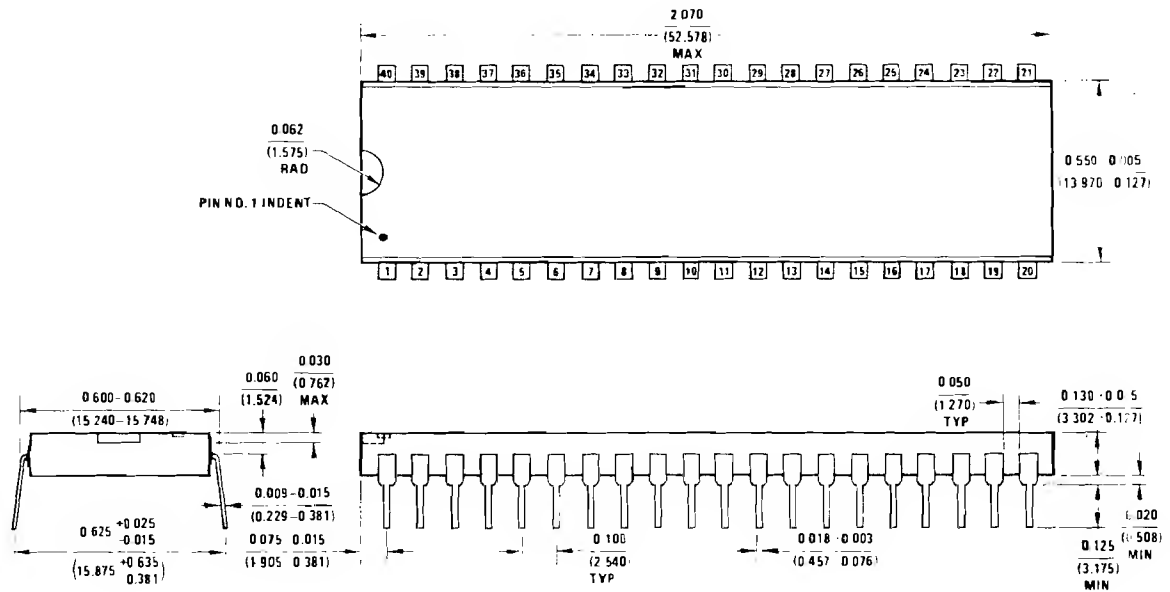


Figure 2. Typical Interface for a High-Capacity Data Bus

Physical Dimensions



Ceramic Dual-In-Line Package (D)
Order Number INS8250D



Plastic Dual-In-Line Package (N)
Order Number INS8250N

Manufactured under one or more of the following U.S. patents: 3083262, 3189758, 3231797, 3303356, 3317671, 3323071, 3381071, 3408542, 3421025, 3426423, 3440498, 3518750, 3519897, 355431, 3560765, 3566218, 3571630, 3575609, 3579059, 3593069, 3597640, 3607469, 3617859, 3631312, 3633052, 3638131, 3648071, 3651565, 3693248

National Semiconductor Corporation
2900 Semiconductor Drive, Santa Clara, California 95051, (408) 737-5000/TWX (910) 339-9240
National Semiconductor GmbH
808 Fuerstentfeldbruck, Industriestrasse 10, West Germany, Tele. (08141) 1371/Telex 05-27649
National Semiconductor (UK) Ltd.
Larkfield Industrial Estate, Greenock, Scotland, Tele. (0475) 33251/Telex 778-632

